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PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a r qu st for filing a PROVISIONAL APPLICATION FOR PATENT und r 37 CFR 1.53 (c).

INVENTOR(S)

Given Name (first and middle [if any])	Family Name or Surname	Residence (City and either State or Foreign Country)
Peter	Isberg	Västerås, Sweden

☐ *Additional inventors are being named on the ____ separately numbered sheets attached hereto*

TITLE OF THE INVENTION (280 characters max)

Contact arrangement

CORRESPONDENCE ADDRESS

Direct all correspondence to:

☒ Customer Number 23517 → *Place Customer Number Bar Code Label here*

Type Customer Number here

OR

☐ Firm or Individual Name	Eric J. Franklin, Swidler Berlin Shereff Friedman, LLP				
Address	3000 K Street, NW				
Address	Suite 300				
City	Washington	State	D.C.	ZIP	20007
Country	USA	Telephone	202 424-7500	Fax	202 295 8478

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Respectfully submitted,

SIGNATURE Eric Franklin

Date October 16, 2003

TYPED or PRINTED NAME Eric J. Franklin

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Contact arrangement

TECHNICAL FIELD

An element for making an electric contact to a contact member for enabling an electric current to flow between said element and said contact member. The element comprising a body having at least a contact surface thereof coated with a contact layer to be applied against said contact member. The contact layer comprises a continuous or discontinuous film comprising a multielement material. The multielement material has equal composition as any of a layered carbide and nitride that can be described as $M_{n+1}AX_n$ or M_2 BX, where M is a transition metal or a combination of a transition metals, n is 1, 2, 3 or higher, A is an group A element or a combination of a group A element, B is an group B element or a combination of a group B element and X is Carbon, Nitrogen or both.

BACKGROUND ART

Recent studies has shown that compounds having the general formula $M_{n+1}AX_n$ exhibit unusual and exceptional mechanical properties as well as advantageous electrical thermal and chemical properties. Despite having high stiffness these ceramics are readily machinable, resistant to thermal shock, unusually damage tolerant, have low density and are thermodynamically stable at high temperatures (up to 2300°C in vacuum).

$M_{n+1}AX_n$ compounds have layered and hexagonal structures with $M_{n+1}X_n$ layers interleaved with layers of pure A and this is a anisotropic structure which

has exceptionally strong M-X bonds together with weaker M-A bonds, which gives rise to their unusual combination of properties.

$M_{n+1}AX_n$ compounds are characterized according to the number of transition metal layers separating the A-group element layers: in 211 compounds there are two such transition metal layers, on 312 compounds there are three and on 413 compounds there ore four. 211 compounds are the most predominant, these include Ti_2AlC, Ti_2AlN, Hf_2PbC, Nb_2AlC, $(NB,Ti)_2AlC$, $Ti_2AlN_{0,5}C_{0,5}$, Ti_2GeC, Zr_2SnC, Ta_2GaC, Hf_2SnC, Ti_2SnC, Nb_2SnC, Zr_2PbC and Ti_2PbC. The only known 312 compounds are Ti_3AlC_2, Ti_3GeC_2 and Ti_3SiC_2. Ti_4AlN_3, Ti_4SiC_3 and Ti_4GeC_3 are the only 413 compounds known to exist at present. A very large number of solid solution permutations and combinations are also conceivable as it is possible to form solid solutions on the M-sites, the A-sites and the X-sites of these different phases.

The $M_{n+1}AX_n$ compounds can be in ternary, quaternary or higher phases. Ternary phases has three elements, i.e. Ti_3SiC_2, quaternary phases has four elements i.e. $Ti_2AlN_{0,5}C_{0,5}$, and so on. Thermally, elastically, chemically and electrically the ternary, quaternary or higher phases share many of the attributes of the binary phases.

Michael Barsoum has synthesized, characterized and published data on the $M_{n+1}AX_n$ phases named above in bulk form ["The $M_{n+1}AX_n$ Phases: A New class of Solids", Progressive Solid State Chemistry, Vol. 28 pp201-281, 2000]. His measurements on Ti_3SiC_2 show that it has a significantly higher thermal conductivity and a much lower electrical resistivity than titanium and, like other $M_{n+1}AX_n$ phases, it has ability to contain and confine damage to small areas thus preventing/limiting crack propagation through the material. Its layered structure and the fact that bonding between the layers is weaker than along the

layers (as in graphite) give rise to a very low friction coefficient, even after six months exposure to atmosphere.

A contact element including a contact layer comprising a multielement material with equal composition as any of a layered carbide and nitride that can be described as $M_{n+1}AX_n$ may have many different applications. The contact element is used for making an electric contact to the contact member for enabling an electric current to flow between said element and said contact member. The element comprise a body having at least a contact surface thereof coated with a contact layer to be applied against said contact member, as well as a sliding electric contact arrangement in which two contact surfaces adapted to be applied to each other for establishing an electric contact may slide with respect to each other when establishing and/or interrupting and/or maintaining the contact action. The contact layer is arranged for establishing a contact to the contact member with desired properties, such as a low contact resistance and low friction coefficient with respect to the material of the contact member to be contacted etc. Such applications are for instance for making contacts to semiconductor devices for establishing and interrupting electric contact, in mechanical disconnections and breakers and for establishing and interrupting electric contacts in contact arrangements of plug-in type. Such electric contact elements, which may establish sliding contacts or stationary contacts has preferably a body made of for instance copper or aluminium.

An example of a contact element including a contact layer, such as a continuous film of a multielement material having strong bonds, such as covalent or metallic bonds, within each atomic layer and weaker bonds, through longer bonding distance or for van der Waals bonds or hydrogen bonds, between at least some adjacent atomic layers thereof is given in WO01/41167. The multielement material is MoS_2, WS_2 or equals the composition of any of layered ternary carbides and nitrides that can be described as M_3AX_2. The M_3AX_2 ceramics show a potential to replace other exclusive metals in contact

applications. The M_3AX_2 ceramics, however, has a limited electrical conductance compared to Ag and Au and there is generally a native oxide formed on the surface.

SUMMARY OF THE INVENTION

The object of the present invention is to provide an electric contact element having a contact layer with a low friction without the disadvantages mentioned above of such layers already known in connection with use and/or manufacture thereof.

This object is according to the invention obtained by providing such a contact element with a metal layer. The contact element having a contact layer comprising a multielement material with equal or similar composition as any of a layered carbide and nitride that can be described as $M_{n+1}AX_n$ or M_2 BX, where M is a transition metal e.g. Ti, Zr, Nb, W, Cr or a combination of a transition metals, n is 1, 2, 3 or higher, A is a group A element e.g., Si, Ge, Sn, Al or a combination of a group A element, B is an group B element or a combination of a group B element and X is Carbon and/or Nitrogen.

In an embodiment of the invention the composition of the multielement material is equal or similar to a any of a layered carbide and nitride that can be described as $M_{n+1}AX_n$ or M_2 BX. The multielement material is a nanocomposite in amorphous state or nanocrystalline (0.5-500 nm grain size) state with a composition $M_xA_yX_z$ where $\{0 \leq x, y, z \leq 1; x+y+z=1\}$ or both.

It has been found that low temperature deposition of the multielement laminated structure results in nanocompsites films, with single element, binary and ternary phases, with good chemical and contact properties. The composition of the film on an average should be equal or similar to the

composition of the layered ceramic described above. The nanocomposite films shows also the desired ductile behaviour, posses non welding properties, shock resistance, chemical inertness, low contact resistance and good high temperatures properties which are all desired properties in electrical contacts.

The element for making an electric contact to another contact element here called contact member for enabling an electric current to flow between said element and said contact member, comprising a body having at least a contact surface thereof coated with a contact layer. The contact layer is applied against said contact member. The contact layer comprises a continuous or discontinuous film. The film comprises a multielement material with equal composition as any of a layered carbide and nitride that can be described as $M_{n+1}AX_n$ or M_2BX. The film also comprise a metallic layer, the thickness of the metallic layer is in the range of a fraction of an atomic layer to 1000 μm.

It has turned out that a film comprising said multielement material, and a metallic layer is excellent as a contact layer on a contact element in question for many reasons. A contact layer comprising a multielement material, and a metallic layer according to the invention used as a contact has low contact resistance. The friction coefficient thereof is very low, typically 0.1-0.4. The metallic layer provides the low contact resistance. Furthermore, in regions where the contact has a high friction said metallic layer can be worn and the said underlying $M_{n+1}AX_n$ ceramic material appears on the surface and reduces the friction. Furthermore, said underlying $M_{n+1}AX_n$ ceramics provide a low friction and wear resistance. Furthermore, said underlying $M_{n+1}AX_n$ ceramics also is a mechanical load carrying structure with ductile properties under the thin metallic film. This is due to the fact that the strong bonded M-X layers are arranged alternating with weaker M-A bonds. The bonds between these layers in the multielement material are weak. Accordingly, when multielement material of this type comes into contact with another layer only the uppermost atom

layer is sheared against the opposite surface of said contact member resulting in very low friction. The low temperature films are showing equal properties compared to films that possesses a layered crystalline structure. The chemical inertness and the smoothness of the multielement film also contribute to a low friction. The multielement material are relatively chemical inert and stable at temperatures exceeding 400°C. Furthermore, said materials have low tendency to form oxides, which prevent degradation of electric contact to said contact member. Furthermore said multielement material coated or combined with a metallic layer show a ductile performance.

According to a preferred embodiment of the invention the multielement material of said film is formed in that the multielement material is coated with the metallic layer.

According to another preferred embodiment of the invention the multielement material of said film is formed in that the multielement material is blended in the metallic layer.

According to another preferred embodiment of the invention the multielement material of said film has a coat of said metallic layer, in that the contact surface is metallic.

According to another preferred embodiment of the invention said film has a multilayer structure, said multielement material layer is laminated with metallic layers in a repeated manner.

Furthermore said metallic layer is e.g. Au, Ag, Pd, Pt, Rh or an alloy of metals. The metallic layer preferably comprises a noble metal.

Furthermore said metallic layer is any metal or metal composite where the composite can be an oxide, carbide, nitride or boride.

Furthermore said metallic layer is any metal or metal composite, said composite comprising a polymer, an organic material or a ceramic material such as an oxide, carbide, nitride or boride.

According to another preferred embodiment of the invention said film is deposited on said body and adheres thereto.

According to another preferred embodiment of the invention said film is arranged as free standing foil to be applied against said contact member when making said electric contact.

According to another preferred embodiment of the invention said film is doped by one or several compounds for altering and improving friction, mechanical, thermal and electrical properties of said film.

According to another preferred embodiment of the invention said film is formed on said body by means of an chemical method such as an electroless or a electrolytic process.

According to another preferred embodiment of the invention said film is deposited on said body by the use of a vapour deposition technique.

According to another preferred embodiment of the invention said film is deposited on said body by Physical Vapour Deposition (PVD) or Chemical Vapour Deposition (CVD).

According to another preferred embodiment of the invention said film is deposited on said body by dipping the body in a chemical solution or spraying it on said body through for example thermal or plasma spraying.

According to another preferred embodiment of the invention said film is deposited using a combination of the afore mentioned techniques.

A said $M_{n+1}AX_n$ ceramic compounds will have a morphology varying from amorphous or nanocrystalline to pure crystalline, and the morphology may be selected in accordance with the particular use of the contact element and /or the costs for producing the film.

According to a preferred embodiment of the invention the multielement material of said film coated or combined with a metallic layer is in the range 0.001 μm to 1000 μm, and in a very preferred embodiments is less then 5 μm. Said film of metallic layer is in the range of a fraction of an atomic layer to 1 mm. Such thin layers may have a lifetime being nearly indefinite thanks to the very low friction and wear resistance of this material, so that in closed systems the result aimed at will be achieved through a very thin film having low costs of material and manufacturing process as a consequence thereof.

According to another a preferred embodiment of the invention the multielement material coated or combined with a metallic layer is above 10 μm. Such a thickness is preferred in the case of using such a film on a contact element in a contact arrangement where the contact element and the contact member are going to be moved with respect to each other, such as in a sliding contact, and accordingly not only moved by different coefficients of thermal expansion upon thermal cycling, such as when used on a slip ring in an electric rotating machine.

According to another preferred embodiment of the invention the body deeper under said contact surface is made of material being non-resistant to corrosion, and the material last mentioned is coated by a corrosion resistant material such as nickel, adapted to receive said film on top thereof. It is preferred to proceed

in this way, since the multielement material film may have pores with a risk of corrosion of the underlying body material therethrough.

Another object of the present invention is to provide sliding electric contact arrangement of the type defined in the introduction allowing a movement of two contact surfaces applied against each other while reducing the inconveniences discussed above to a large extent.

This object is according to the invention obtained by providing such an arrangement with a contact element according to the present invention with said film arranged to form a dry contact with a very low friction coefficient, below 0.2, preferably below 0.1, to a contact member.

The basic features and advantages of such a contact arrangement are associated with the characteristics of the contact element according to the present invention and appear from the discussion above of such a contact element. However, it is pointed out that a "sliding electric contact" includes all types of arrangements making an electric contact between two members, which may move with respect to each other when the contact is established and/or interrupted and /or when the contact action is maintained. Accordingly, it includes not only contacts sliding along each other by action of an actuating member, but also so called stationary contacts having two contact elements pressed against each other and moving with respect to each other in the contacting state as a consequence of magnetostriction, thermal cycling and materials of the contact elements with different coefficients of thermal expansion or temperature differences between different parts of the contact elements varying over the time.

A contact arrangement of the type last mentioned constitutes a preferred embodiment of the present invention, and the contact elements may for instance be pressed with a high pressure, preferably exceeding 1 MPa against

each other without any mechanical securing means, but the contact elements may also be forced against each other by threaded screws or bolts.

According to another preferred embodiment of the invention said contact arrangement is adapted to be arranged in an electric rotating machine, where the film comprising multielement material will result in a number of advantages. It is in particular possible to benefit from the low friction coefficient of the multielement material when arranging the contact element and the contact member of the contact arrangement on parts of the rotating machine moving with respect to each other, such as for instance the slip ring as a contact element and a contact element sliding thereupon. It will in this way be possible to replace the carbon brushes used in the electric rotating machines by a contact element according to the present invention and a film of said type is then also preferably arranged on the moving part, such as a slip ring. Said carbon brushes have a number of disadvantages, such as a restricted lifetime, since the carbon is consumed. Furthermore, carbon dust is spread out on the windings and other parts of the machine, which may disturb the function thereof. It is preferred to have a thickness of the film of multielement material exceeding 10 μm for such a contact element, since also the film of multielement material will be consumed, but comparatively slowly, in this application thereof.

Electrical contacts arrangements according to other preferred embodiments of the invention are different kinds of contacts having contact surfaces moving while bearing against each other in establishing and/or interrupting an electric contact, such as plug-in contacts or different types of spring-loaded contacts, in which it is possible to take advantage of the very low friction coefficient of a multielement material resulting in a self-lubricating dry contact without the problems of lubricants such as oils or fats while making it possible to reduce the operation forces and save power consumed in actuating members.

Electrical contacts arrangements according to other preferred embodiments of the invention are included in tap changers on transformers, where a low friction is a great advantage when the contact elements are sliding with their contact surfaces against each other, and in mechanical disconnectors and breakers and in relays.

The invention also relates to a use of the contact arrangement according to any of the claims according to the invention relating to a contact arrangement, in which a probe for measuring and testing an integrated circuit is covered with said multielement material film, a contact layer is coated/combined with a metallic layer, avoiding chemical degradation and metal cladding on the probe. It is self evident that this use according to the invention is very favourable, since it will make it possible to carry out measurements and testing without any interruptions for replacing or cleaning the probe.

The invention also relates to a use of the contact arrangement according to any of claims according to the invention relating to a contact arrangement in witch a contact for enabling contact to an electronic device, such as an integrated circuit (IC) is covered with a said multielement material film enabling electrical contact to the device.

Further advantages as well as advantageous features appear from the following description and the other dependent claims.

BRIEF DESCRIPTION OF THE DRAWINGS

With reference to the appended drawings, below follows a specific description of preferred embodiments of the invention. In the drawings;

Figure 1 illustrates an electric contact element of plug-in type according to a preferred embodiment of the invention,

Figure 2 is a sectioned view of an electric contact element of helical contact type according to another preferred embodiment of the invention,

Figure 3 is a partially sectioned and exploded view of an arrangement for making an electric contact to a power semiconductor device according to a preferred embodiment of the invention,

Figure 4 illustrates very schematically a sliding contact arrangement in an electric rotating machine according to a further embodiment of the invention,

Figure 5 illustrates very schematically a contact arrangement according to the present invention in a disconnector,

Figure 6 illustrates very schematically a sliding contact arrangement in a tap changer of a transformer according to a preferred embodiment of the invention,

Figure 7 illustrates very schematically a contact arrangement according to the present invention in a relay,

Figure 8 illustrates very schematically a contact arrangement of a contact arrangement according to a preferred embodiment of the invention in electrical equipment,

Figure 9 depicts a structure of a multielement material layer and a metallic layer,

Figure 10 depicts a structure of a multielement material layer and a metallic layer,

Figure 11 depicts a structure of grains of a multielement material and a metallic layer interleaving the multielement grains, and

Figure 12 depicts a structure of a multielement material layer laminated with metallic layers in a repeated structure.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Figure 1 shows a contact arrangement 1 of plug-in type, in which a contact surface 2 on a contact element 3 slides along and while bearing against contact surfaces 4 on another contact element 5, here called contact member. The contact element 3 has a female character and is present in the form of a resilient jaw adapted to be connected to the male contact member 5 in the form of a contact rail. The contact element 3 is applied on the contact member 5 and bears in the contacting state while being biased by means of at least a contact surface 2 against a contact surface 4 on the contact member 5.

At least one of the contact surfaces 2 and 4, preferably both, are provided with a continuous or discontinuous multielement material film said film comprising a metallic layer, and a multielement material comprising a composition corresponding or is similar to a new class of layered carbides and nitrides that can be described as $M_{n+1}AX_n$ M is a transition metal, A is a group A element (such as 3A and 4A) and X is either C or N. The class of material is also denoted as (n+1)1(n) ceramics. The multielement material could also have a composition corresponding to or is similar to a H-phase material that can be described as M_2BX, where M is a transition metal; B is a group B element and X is either C or N. This film may be very thin with a thickness in the range of 0.001 µm to 1000 µm, and it will have a very low friction coefficient, typically 0.01 to 0.1. This means that the friction forces to be overcome when controlling the contact arrangement for establishing or interrupting the electric contact will be very low, resulting in a low necessary power consumption in an actuating

member and a nearly neglectible wear of the of the contact surfaces constituted by this film. Furthermore, the film is chemical inert and stable at temperatures exceeding 400°. It is pointed out that it is well possible that said continuous or discontinuous film is arranged on only the contact member 5, which of course is a contact element just as the contact element 3. Furthermore, in this case the film comprising multielement material is deposited and adheres to the body 6 of the contact element 3, but in other preferred embodiments of the invention it is well possible that said film coats a body being laid on top thereof as a separate foil. This may in particular be the case for the embodiment shown in Fig. 3 described further below. The continuous or discontinuous film comprising the multielement material may be deposited on the body of the contact element, being preferably of Cu, by different kinds of Physical Vapour Deposition (PVD), Chemical Vapour Deposition (CVD), electrochemically, electroless deposition or with thermal plasma spraying. It is preferred to provide a thin layer of a corrosion resistant material on the body before applying said film would the body be of a material being non-resistant to corrosion, since it is possible that the film will have some pores reaching therethrough.

Fig 2 illustrates a further example of a contact arrangement in which it is advantageous to coat at least one of the contact surfaces with a continuous or discontinuous film comprising a multielement material, and a metallic layer, said film forming a self lubricating dry contact with a very low friction according to the present invention. This embodiment relates to a helical contact arrangement having a contact element 7 in the form of a spring-loaded annular body such as a ring of a helically wound wire adapted to establish and maintain an electric contact to a fist contact member 8, such as an inner sleeve or a pin, and a second contact member 9, such as an outer sleeve or a tube. The contact element 7 is in contact state compressed so that at least a contact surface 10 thereof will bear spring-loaded against a contact surface 11 of the first contact member 8, and at least anther contact surface 12 of the fist contact

element 7 will bear spring-loaded against at least a contact surface 13 of the second contact member 9. According to this preferred embodiment of the invention at least one of a contact surfaces 10-13 is entirely or partially coated with a continuous or discontinuous low friction film comprise a multielement material, and a metallic layer. Such a helical contact arrangement is used for example in an electrical breaker in a switchgear device.

An arrangement for making a good electric contact to a semiconductor component 14 is illustrated in Fig 3, but the different members arranged in a stack and pressed together with a high pressure, preferably exceeding 1 MPa and typically 6-8 MPa, are shown spaced apart for clarity. Each half of the stack comprises a pool piece 15 in the form of a Cu plate for making a connection to the semiconductor component. Each pool piece is provided with a thin continuous or discontinuous film 16 comprising multielement material, and a metallic layer. The coefficient of thermal expansion of the semiconductor material, for instance Si, SiC or diamond, of the semiconductor component and of Cu differs a lot ($2{,}2 \cdot 10^{6}$/K for Si and $16 \cdot 10^{-6}$/K for Cu), which means that the Cu plates 15 and the semiconductor component 14 will move laterally with respect to each other when the temperature thereof changes. Contact arrangements of this type according to the stand of the art require for that sake one or several further members in said stack between the pool piece and the semiconductor component for taking care of this tendency to mutual movements upon thermal cycling for avoiding cracks in the semiconductor component and/or wear of the contact surface of said component. However the very low friction of a film according to the present invention makes it possible to omit all these additional members and making the contact arrangement less costly, not at the least by allowing the issue of a cheap material without any need of thermal matching close to there semiconductor component. A contact arrangement of this type is a part of power electronic encapsulation 17 forming a closed system, and practically no material will be consumed when the film moves along the semiconductor component upon thermal cycling so that the

lifetime thereof will be practically indefinite. The multielement contact layer 16 with the metallic film can also be deposited directly on the semiconducting device 14 or both on the Cu pole piece 15 and the device 14.

A sliding contact arrangement according to another preferred embodiment of the invention is schematically illustrated in Fig 4 as used in an electric rotating machine 18 of any type for establishing an electric contact between a slip ring 19 and ac contact element 20, which here replaces a carbon brush and is made of a body for instance copper or aluminium coated with a continuous or discontinuous film indicated at 22. This results in a very low friction electric contact having a low contact resistance. It would also be possible to use a contact arrangement having a continuous or discontinuous film of multielement material between two members moving with respect to each other in an electric rotating machine for avoiding a static electricity to be built up.

Fig 5 illustrates very schematically how an electric contact arrangement according to the invention may be arranged in a disconnector 23 with a low friction film 24, comprising a multielement material, and a metallic layer, on at least one of the contact surfaces of two contact elements 25, 26 movable with respect to each other for establishing an electric contact there between and obtaining a visible disconnection of the contact elements.

Fig 6 illustrates schematically a sliding electric contact arrangement according to another preferred embodiment of the invention, in which the contact element 27 is a movable part of a top changer 28 of a transformer adapted to slide in electric contact along contacts 29 to the secondary contact member, for tapping voltage of a level desired from said transformer. A low friction film 30, comprising a multielement material, and a metallic layer, is arranged on the contact surface of the contact element 27 and/or on the contact member 29. The contact element 27 may in this way be easily moved along the winding 29 while maintaining a low resistance contact thereto.

Fig 7 illustrates very schematically a contact arrangement according to another preferred embodiment of the invention used in a relay 31, and one or both of the contact surfaces of opposite contact elements 32, 33 may be provided with a low friction film 34 comprising a multielement material, which will result in less wear of the contact surfaces due to lower tendency of welding and make them corrosion resistant as a consequence of the character of multielement material.

Figure 8 illustrates very schematically an electric contact arrangement of plug-in type, for example used in electrical equipment. The contact arrangement has a first contact member 41, which has male character, and second contact member 42, which has female character. The first contact member 41 is adapted to be connected to the second contact member 42, by means of at least a contact surface 43 on the first contact member against a contact surface 44 on the second contact member.At least one of the contact surfaces 43 and 44, preferably both, are provided with a continuous or discontinuous multielement material film said film comprising a metallic layer, and the multielement material.

Figure 9 depicts a structure of a multielement material, an inert $M_{n+1}AX_n$ or H-phase layer D and a metallic layer M.

Figure 10 depicts a structure of a multielement layer corresponding or is similar to the composition of a $M_{n+1}AX_n$ or H-phase compounds and a metallic layer M. Individual regions (denoted C, D and E in the picture) in the structure can be single element, binary, ternary and quaternary phases.

Figure 11 depicts a structure of grains of a multielement material corresponding or is similar to the composition of a $M_{n+1}AX_n$ or H-phase compounds combined in a metallic layer. Individual grains (denoted C, D and E in the

picture) in the structure can be single elements, binary, ternary and/or quaternary phases.

Figure 12 depicts a structure of a layer of ternary multielement layer corresponding or is similar to the composition of a $M_{n+1}AX_n$ or H-phase compounds laminated with metallic layers M in a repeated structure. Individual regions in the compounds can also be single elements, binary, ternary and/or quaternary phases (denoted C, D and E in the picture).

A contact element and a sliding electric contact arrangement according to the present invention may find many other preferred applications, and such applications would be apparent to a man with ordinary skill in the art without departing from the basic idea of the invention as defined in the appended claims.

It would for example be possible to dope the thin friction film for improving friction, thermal, mechanical or electrical properties by one or several compounds. However, the amount of doping should not exceed 20 weight-% of the film. It is then also possible to have different films on different contact surfaces of the contact elements and the contact member, for instance some doped and others not or some formed by at least two sub-layers and others having only one layer.

Another example of a contact arrangement according to the invention is to cover a probe for measuring and testing an integrated circuit (IC) with said film, comprising a multielement material and a metal layer, avoiding chemical degradation and metal cladding on the probe.

Furthermore, the contact elements and arrangements of the invention are not restricted to any particular system voltages, but may be used on low, intermediate and high voltage applications.

The multielement material of the contact layer according to the invention may form an solid film together with 50-90% of metal, for instance of Ti or Au, for improving the conductivity. This may take place by forming a homogeneous dispersion of the metal in the material, inhomogeneous dispersion with metallic regions and multielement regions, such as a composite or by arranging a layer of the multielement chemical compound and a layer of the metal alternatingly.

CLAIMS

1. An element for making an electric contact to a contact member (5, 15, 19, 33, 41) for enabling an electric current to flow between said element and said contact member, said element (3,14, 20, 32, 42) comprising a body (6) having at least a contact surface (2, 4, 16, 21, 22, 24, 30, 34, 43, 44) thereof coated with a contact layer applied against said contact member, and that said contact layer comprises a film comprising a multielement material with equal composition as any of a layered carbide and nitride that can be described as $M_{n+1}AX_n$ or M_2BX, where M is a transition metal or a combination of a transition metals, n is 1, 2, 3 or higher, A is an group A element or a combination of a group A element, B is an group B element or a combination of a group B element and X is Carbon, Nitrogen or both, **characterised in** that said multielement material a nanocomposite of single element, binary, ternary or higher order phases based on the constituents in the corresponding $M_{n+1}AX_n$ or M_2BX phases and that said film comprise a metallic layer, the thickness of the metallic layer is in the range of a fraction of an atomic layer to 1000 µm

2. An element according to claim 1, **characterised in** that said nanocomposite comprise at least one of the following: MX, MA_nX, X, $M_{n+1}AX$ or a combination of said materials.

3. An element according to claim 1 or 2, **characterised in** that said multielement material has a coat of said metallic layer, in that the contact surface is metallic.

4. An element according to any of the claims 1-3, **characterised in** that said multielement material layer is laminated with metallic layers in a multilayer structure.

5. An element according to any of the claims 1-3, **c h a r a c t e r i s e d i n** that said multielement material comprise individual regions (C, D, E) that can be single element, binary, ternary and/or quaternary phases of said layered carbide and nitride.

6. An element according to any of the claims 1-3, **c h a r a c t e r i s e d i n** that the metallic layer covers grains or regions of the multielement material, with the total film thickness is in the range 0.0001 μm to 1000 μm.

7. An element according to any of the preceding claims, **c h a r a c t e r i s e d i n** that the thickness of the metallic layer in the range of a fraction of an atomic layer to 5 μm.

8. An element any of the preceding claims, **c h a r a c t e r i s e d i n** that the thickness of the metallic layer in the range 1 nm to 1000 μm.

9. An element according to any of the preceding claims, **c h a r a c t e r i s e d i n** that said metallic layer is any of Au, Ag, Pd, Pt, Rh or an alloy with at least one of of any of the afore mentioned metals.

10. An element according to any of the preceding claims, **c h a r a c t e r i s e d i n** that said metallic layer is any metal or a metal alloy.

11. An element according to any of the preceding claims, **c h a r a c t e r i s e d i n** that said metallic layer is any metal or metal composite where the composite can be an oxide, carbide, nitride or boride.

12. An element according to any of the preceding claims, **c h a r a c t e r i s e d i n** that said metallic layer is any metal or metal

composite, said composite comprising a polymer, an organic material or a ceramic material such as an oxide, carbide, nitride or boride.

13. A element according to any of the preceding claims, **characterised in** that said film is continuous.

14. A element according to any of the preceding claims, **characterised in** that said film is deposited on said body and adheres thereto.

15. A contact element according to any of the claims 1-13, **characterised in** that said film is arranged as freestanding foil to be applied against said contact member when making said electric contact.

16. A contact element according to any of the preceding claims, **characterised in** that said film is doped by one or several compounds for altering and improving friction, mechanical, thermal and electrical properties of said film.

17. A contact element according to claim 14, **characterised in** that said film is formed on said body by means of an chemical method such as a electroless or a electrolytic process.

18. A contact element according to claim 14, **characterised in** that said film is deposited on said body by the use of a vapour deposition technique.

19. A contact element according to claim 18, **characterised in** that said film is deposited on said body by Physical Vapour Deposition (PVD) or Chemical Vapour Deposition (CVD).

20. A contact element according to claim 14, **characteris d in** that said film is deposited on said body by dipping the body in a chemical solution or spraying it on said body through for example thermal or plasma spraying.

21. A contact element according to claim 14, **characterised in** that said film is deposited using a combination of the techniques according to claims 13-19.

22. A sliding electric contact arrangement, i.e. a contact arrangement in which two contact surfaces (2, 4) adapted to be applied against each other for establishing an electric contact may slide with respect to each other when establishing and/or interrupting and/or maintaining the contact action, **characterised in** that it has a contact element (3, 42) according to any of the preceding claims with said film arranged to form a dry contact with a very low friction coefficient, below 0.6, preferably below 0.1, to a contact member (5, 41).

23. An arrangement according to claim 22, **characterised in** that said contact member (5, 41) has also a contact surface (4) coated with a film comprising a multielement material film.

24. An arrangement according to claim 22 or 23, **characterised in** that the surfaces of the contact element (15) and the contact member (14) adapted to applied against each other for establishing said electric contact are allowed to move with respect to each other as a consequence of magnetostriction or different coefficients of thermal expansion of the materials of surface portions of the contact element and the contact member upon temperature changes of the contact element and the contact member.

25. A contact arrangement according to claim 24, **characterised in** that the contact element (15) and the contact member (14) are adapted to be pressed towards each other for establishing said contact.

26. An arrangement according to claim 25, **characterised in** that the contact element (15) and the contact member (14) are adapted to be forced against each other by bolts or screws for establishing said electric contact there between.

27. An arrangement according to any of claims 22-25, **characterised in** that the contact element (20) and the contact member are adapted to establish an electric contact in an electric rotating machine(18).

28. An arrangement according to claim 27, **characterised in** that the contact element and the contact member are adapted to establish an electric contact between two parts (19,29) of the machine moving with respect to each other when the machine (18) is in operation with the contact element and the contact member arranged on a separate such part.

29. An arrangement according to claim 27, **characterised in** that said moving part is a slip ring (19).

30. An arrangement according to any of claims 22-25, **characterised in** that one (5, 41) of the contact element and the contact member is male-like and the other (3, 42) is female-like, and that the contact element and the contact member are adapted to establish said electric contact by being brought into engagement with each other.

31. An arrangement according to any of claims 22-25, **characterised in** that it comprises means for spring-loading the contact element and the contact member against each other for making said electric contact.

32. An arrangement according to any of claims 22-25, **characterised in** that it is adapted to establish an electric contact in a tap changer(28) for a transformer for making a contact to different winding(29) turns of the transformer.

33. An arrangement according to any of claims 22-25, **characterised in** that one of the contact element and the contact member belong to two parts of a mechanical disconnector movable away from each other for disconnecting two terminals thereof.

34. An arrangement according to any of claims 22-25, **characterised in** that one of the contact element and the contact member belong to two parts of a mechanical breaker movable away from each other for breaking the current path between the terminals thereof.

35. An arrangement according to any of claims 22-25, **characterised in** that one of the contact element and the contact member belong to a crimp contact.

36. An arrangement according to any of claims 22-25, **characterised in** that one of the contact element (32) and the contact member (33) belong to the parts movable with respect to each other in a relay for establishing an electric contact there between when the relay operates.

37. A method for creating a thin layer on a contact member for making a good electric contact of said contact member to a contact member for connection to said contact member and having a low friction coefficient with respect to said contact members pressed together for forming said good electric contact, **characterised in** that that the multielement material is coated with the metallic layer.

38. A method for creating a thin layer on a contact member for making a good electric contact of said contact member to a contact member for connection to said contact member and having a low friction coefficient with respect to said contact members pressed together for forming said good electric contact, characterised in that the multielement material is blended in the metallic layer.

39. Use of a contact arrangement according to any of claims 22-36 in witch a contact for enabling contact to a electronic device, such as an integrated circuit (IC) is covered with a said multielement material film enabling electrical contact to the device.

40. Use of a contact arrangement according to any of claims 22-36 in witch a probe for measuring and testing an integrated circuit (IC) is covered with a said multielement material film avoiding chemical degradation and metal cladding on the probe.

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ABSTRACT

An element for making an electric contact to a contact member 5, 15, 19, 33, 41 for enabling an electric current to flow between said element and said contact member. The element 3,14, 20, 32, 42 comprises a body (6) having at least a contact surface 2, 4, 16, 21, 22, 24, 30, 34, 43, 44 thereof coated with a contact layer applied against said contact member. The contact layer comprises a continuous or discontinuous film comprising a multielement material with equal or similar composition as any of a layered carbide and nitride that can be described as $M_{n+1}AX_n$ or M_2BX, where M is a transition metal or a combination of a transition metals, n is 1, 2, 3 or higher, A is an group A element or a combination of a group A element, B is an group B element or a combination of a group B element and X is Carbon, Nitrogen or both. (fig 8)

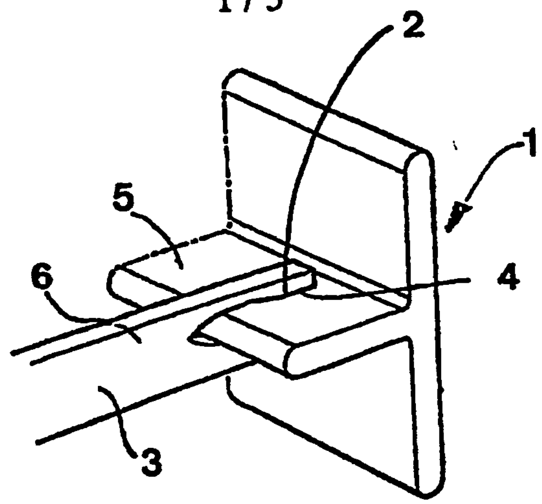
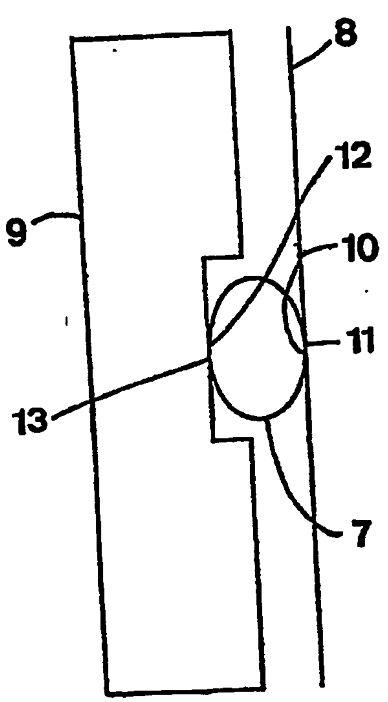


Fig 1



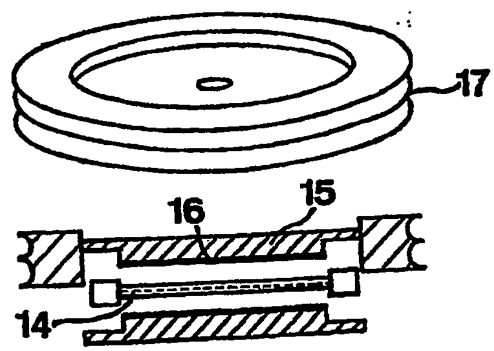


Fig 3

Fig 2

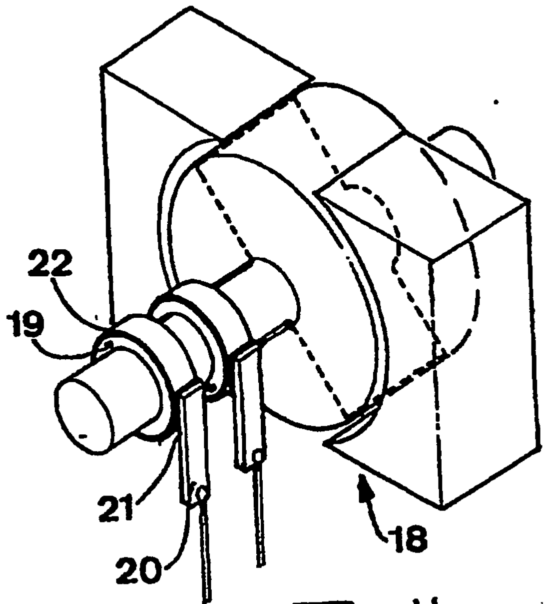


Fig 4

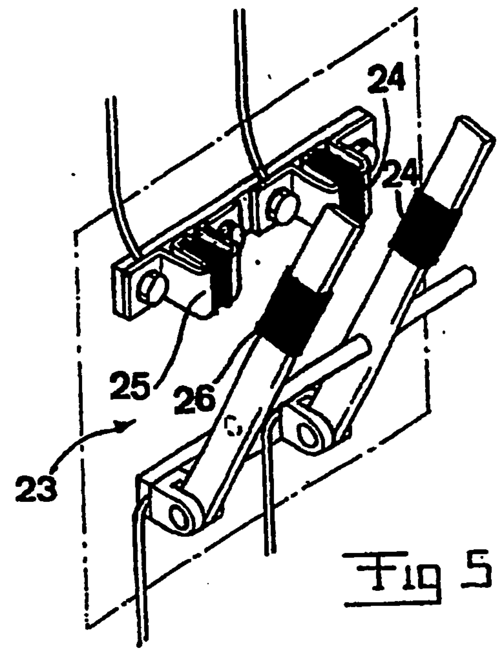


Fig 5

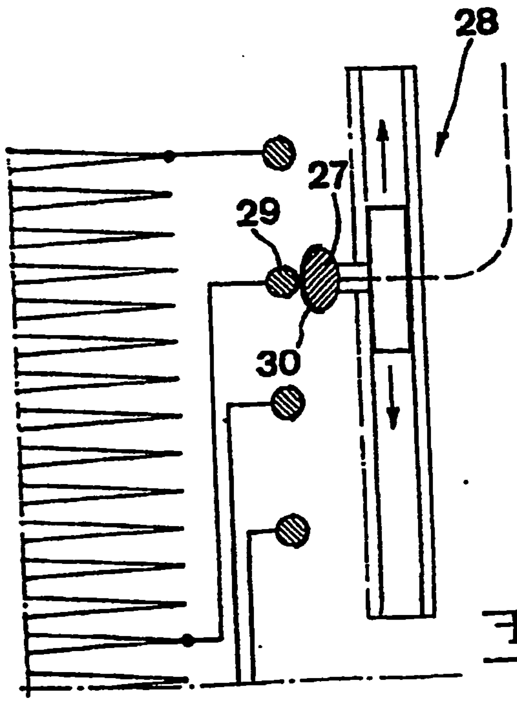


Fig 6

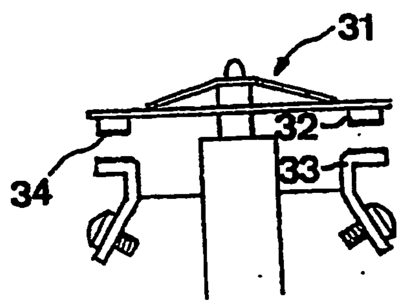


Fig 7

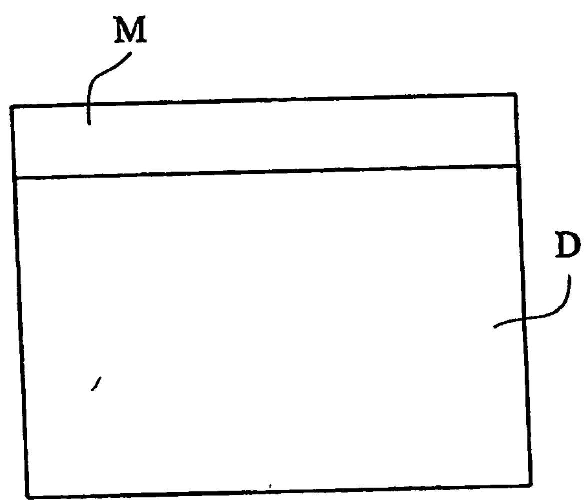


Fig.9

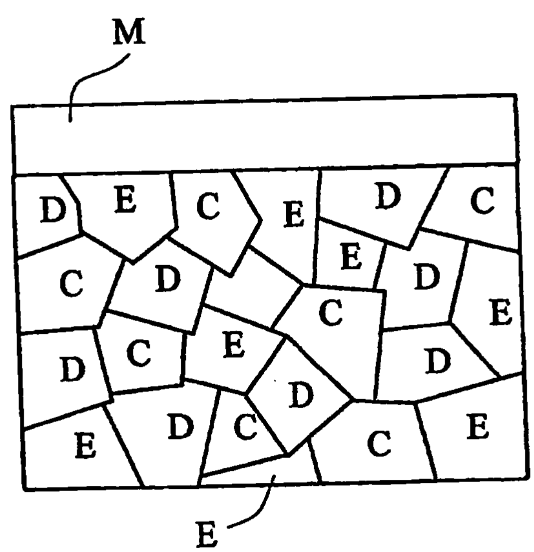


Fig.10

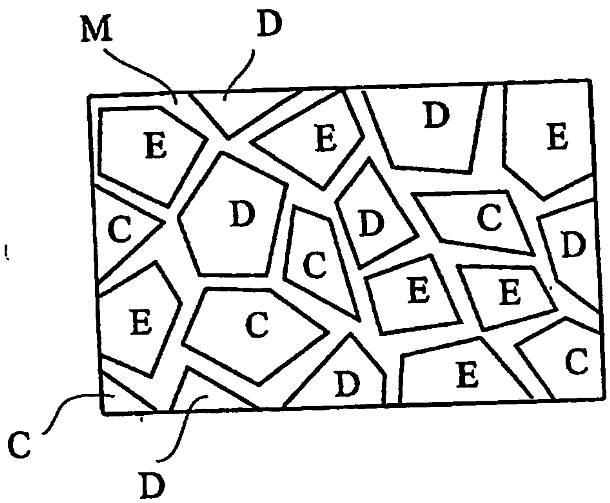


Fig. 11

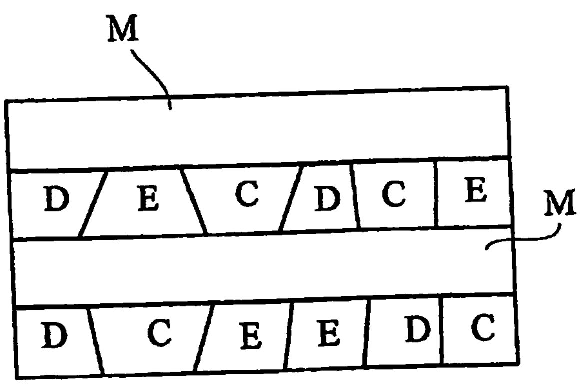


Fig. 12

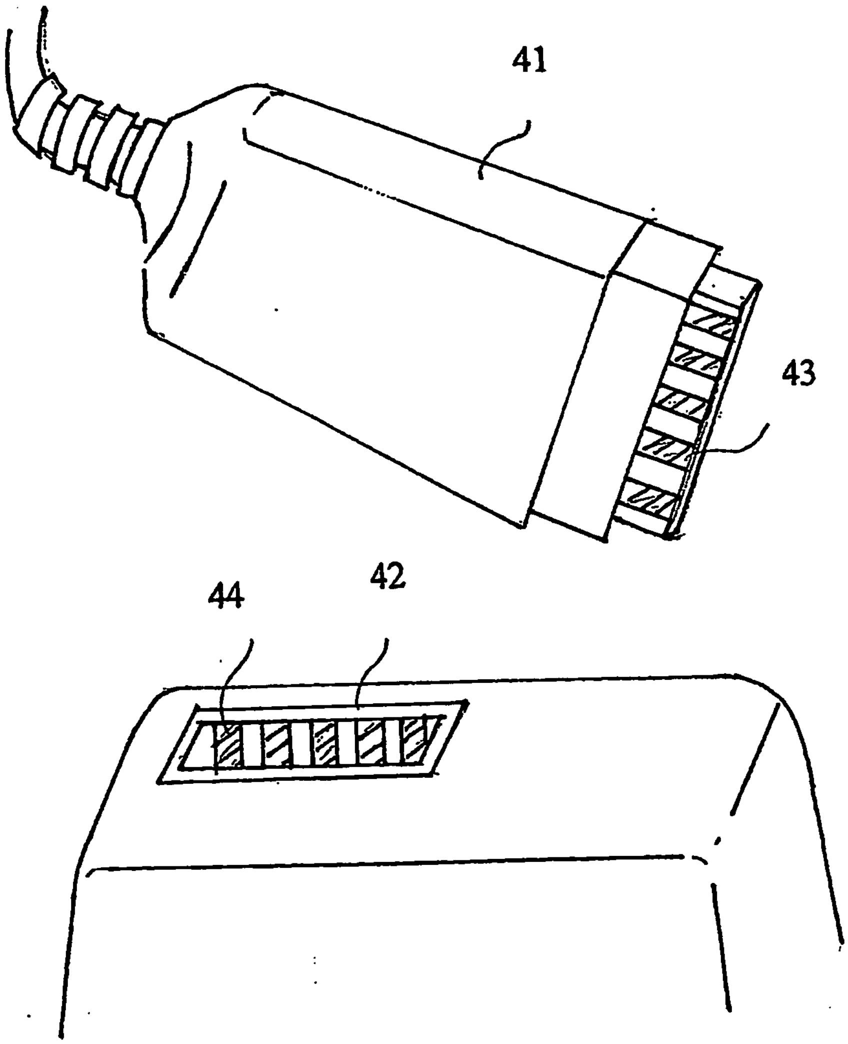


Fig. 8